International Harmonized Research Activities (IHRA)

Biomechanics Working Group

Draft Minutes of Meeting held at INRETS, Lyon, France September 27-28, 1999

Attendees:

Rolf Eppinger	Chair / NHTSA
Dainius Dalmotas	Secretary Transport Canada/Canada
Dominique Cesari	INRETS/EU/EEVC
Steve Moss	FTSS (observer)
Risa Scherer	WorldSID Task Group
Farid Bendjellal	OICA/ Europe
Koshiro Ono	JARI/JMOT Japan
Jac Wismans	EU/EEVC WG12
Suzanne Tylko	Transport Canada/ Canada

Opening of Meeting:
The chair welcomed the delegates.

1. Acceptance of Previous Minutes:
Draft minutes for the meeting held July 12, 1999 in Frankfurt, Germany were distributed by Dainius Dalmotas.

Corrections: Keith Seyer's name was corrected throughout the document.

Under 'Other business' GM was replaced with B. Mertz.

Dominique Cesari moved to accept the minutes as amended and the motion was carried.

2. WorldSID Update (Risa Scherer)

The project is now fully funded.

The design specifications have been frozen and the clarifications completed. There

194 total non-redundant channels (includes fully instrumented legs and arms)

Alpha evaluation will be conducted by Transport Canada and NHTSA.

Europe is interested in participating at least in part, in the evaluation of the α-prototype. SID 2000 has supported the development of the α-prototype.

Application deadline for submissions for funding to support evaluation of the WorldSID from the European commission is Dec.15 with reply expected by March 15.

The plan would be to send the α-prototype to Europe after evaluation at TC and NHTSA is completed. Some coordination would be required to avoid replication of tests.

α-testing will include all ISO biofidelity; glazing/packs; IHRA tests that may have been derived and specified.

Asia will run biofidelity on the β-prototype.

Meetings: SID 2000 meeting planned for October 15 to look at pelvic design;

WorldSID meeting is November 1 in San Diego;

WG5 meeting November 5 in San Diego;

3. WorldSID Design progress report (Steve Moss)

Chest

Spine box will be central rather then rear mounted and the mass will be concentrated to lower inertial spikes. A one piece spine was selected over multi-segmented spine for calibration reasons.

UMTRI Anthropometry database used as a starting point: 1983 study identified a 24.6° angle for the back as measured between T8 and L5;

Modeling included single rib, 10kg spine box, 6.7m/s impact with a 2.4 kg pendulum 75mm deflection (impactor motion): generated maximum strains of 2.2 to 3.3% and 2400N loads. Oblique loading 30° from the front results in maximum strain of 2.3% and highlights deflection measurement issue;

Compared to Wayne State chest band work; model indicates rotational motion of the spine box which is more cadaveric; dummy will need a pivot point or hinge at sternum.

Top three ribs will be connected to the sternum and deflection stops will be included;

Shoulder

Preliminary math modeling had been completed for the shoulder;

Damping material to be used will be equivalent to the standard damping material employed in the Hybrid III;

Need 3 loading conditions for sternum: pure lateral deflection >100mm from outside arm; pre-test positioning and shoulder motion for static airbag tests;

Achieving the desired lateral deflection and static deployment capabilities may prove difficult (impossible) with a single shoulder design

Plan is to design to meet lateral deflection only and provide an alternate shoulder for static deployment. ROM requirement for biofidelity would require a 2 year time frame. Shoulder development may have advanced sufficiently for inclusion into the β-prototype.

Anticipated deflections are as follows:

Arm (20-30 mm); shoulder (70-75 mm) for a total deflection of 90-105 mm.

The deflection path is through the glenoid-humerus joint and involves primarily lateral motion.

The clavicle will likely be plastic based.

Abdomen
Two additional ribs have been added (ribs 4-5);

Abdominal bulge will be modeled in foam;

Lumbar Spine
3° increment setting, similar to THOR;

Increased lateral bending;

Inclusion of an extensible cable (rubber or spring) to allow spine to extend;

Offset support posts to assist in positioning, disappear during the dynamic phase;

Instrumentation
64 in-dummy data acquisition possible with 2 x 32 channel DAS slide-in modules;

Pre-wired harness, no protrusions rearward;

Option to plug in at umbilicus;

Arms and legs will be independent with an umbilical;

IR track can be incorporated for each rib, (also linear pot option, 2 per rib);

IR track length is 150 mm (6 in) gimble is mounted to center.

Comments and thoughts are solicited.

4. Anthropometry report (Steve Moss)

DOC [99-12] Comparison Between Jürgens, UMTRI and RAMSIS Data (Hoofman, Hapee, van Rantingen for EEVC-WG12) circulated; **DOC [99-13]** is a copy of presentation made to WorldSID.

Tabulates body measurements for the 50th percentile male and 5th percentile female using Jürgens (analyzed & presented in July by Keith Seyers); UMTRI; RAMSIS US/ Canada; RAMSIS US in-house; RAMSIS German; RAMSIS Japan/ Korea; RAMSIS Japan in-house.

UMTRI data was reworked to produce a set of 147 points (55 symmetric); generated a full surface model.

SAE Aspect Program ASIS is shifted, and there is too much flesh under the pelvis, H-point is repositioned 10.4 mm lower 2 mm forward, back angle line L5-T8 24.6°.

Comparison of UMTRI stickman to RAMSIS by matching/ overlapping surface landmarks and joint centres.

- Differences in the pelvic angle between RAMSIS and UMTRI, no lordosis in UMTRI
- Upper arm lengths differ

Table DOC [99-13] Base dimensions are similar across all sources

Discussion:
Extensive discussions ensued regarding the feasibility of relying on UMTRI data to represent all population groups;

Rolf Eppinger recalled a study where moments of inertia and masses were found to have less than a 10% effect on response;

Jac Wismans drew attention to an earlier study published in the last ESV proceedings where they looked at extreme sizes in the typical population from RAMSIS and found that injury criteria was greatly affected. Parameters included upper, mid and lower limits for depth/ length/ seating height resulting in 27 categories.

Farid Bendjellal stated that when they were designing their head restraint systems they had to choose each extreme and centre point for each category.

At the moment we seem to have an internally consistent data set, does this still apply when you move away from the 50th percentile male or average person;

The committee must decide between the selection of a 50^{th} percentile male or person. Since the 50^{th} male is in the middle of the distribution adding the 50^{th} female will bring down the average/ median value.

The field data as pointed out by Dainius Dalmotas indicates that the 50^{th} male is at greatest risk of pole impacts while the 5^{th} female represents the cut off for seating positions.

Conclusion
Committee will provide specs for a small, mid and large size dummy for November;

Current UMTRI is acceptable for the mid size dummy;

Further meetings are required to propose anthropometric guidelines for the child dummies;

Tasks

1. Farid Bendjellal will provide a communication with documentation pertaining to positioning i.e.; what is feasible
2. Comparison of UMTRI with Jurgens for the 95^{th} percentile (Jac Wismans);
3. Verification of data values for US/Canada '76 vs. '97 proprietary data (Steve Moss).

5. Biofidelity Test Review

EEVC WG 12 has taken the SID2000 report as a basis and makes recommendations to the European commission regarding future regulations.

The WG reviewed the ISO document of WG5 and started with this as a basis to produce the SID 2000 report. The SID2000 report has been accepted by EEVC WG 12.

Reviews and recommendations **DOC [99-14]** distributed to members. The committee needs to explore how to combine the SID2000 report together with the NHTSA recommendations. The committee agreed to compare and discuss the recommendations as they pertain to each body part.

HEAD

1. Low head drop - rigid impact /high head drop - padded impact

Discussion:
NHTSA would prefer to have two tests to avoid "sweet" spot

EEVC recommends dropping the high drop since the padding is no longer available and the skull should not fracture. HIC is based on fracture data therefor if the fracture test data is dropped then injury criteria will need to be reviewed.

Rigid impact excites high frequencies, lower drop without padding is actually more stringent.

IHRA Recommendation: Retain lower drop only.

2. Pendulum Test

Discussion:
THOR specs include both frontal and lateral.

EEVC is interested in THOR pendulum tests if additional data and exact test procedures can be defined.

Dominique Cesari explained that if acceleration time history is available you can do away with rebound: the members agree that we need to specify something more than just peak g to account for rebound behavior (some data may be available from Kalliaris).

Mass, location of CG with respect to OC and joint centers of rotation needs to be considered in anthropometry.

If possible future work should include oblique test data however since no oblique data is available now we should specify a frontal requirement or mid-point between frontal and lateral, interpolate between frontal and lateral for now.

A good FEM of the skull exists and oblique tests could be run.

Tasks

1. EEVC will review Macintosh tests for next meeting;
2. NHTSA will review THOR tests for next meeting;
3. The committee will compare the two approaches at the next meeting and decide which is more appropriate.

LATERAL NECK

1. 7.2g Sled test based on NBDL data;
2. 6.7g Sled test based on Patrick & Chou;
3. 12.2 g sled test based on APR;

Discussion

NHTSA and EEVC agree on including only test 1 (drop test 2 & 3 due to insufficient sample sizes) with the exception that EEVC would like to get more data to better characterize the head and neck response.

Risa Scherer stated that 9790 gives conflicting design recommendations therefor from a design point of view limiting tests to NBDL would be preferable.

Dominique Cesari pointed out that the problem with eliminating Chou and APR tests is that you are left with only 1 test.

Note: Neck test 1 is also recommended for the shoulder. The loads included in the NHTSA recommendations refer to the shoulder.

Jac Wismans stated that neck loads are calculated from kinematics; Dominique Cesari is more in favor of referencing what was directly measured from the cadaver as opposed to a post calculated value.

Since the bending moment needs to be recorded Jac Wismans recommends that we drop the 30Nm lateral bending requirement (bullet 5)

Tasks

1. Rolf Eppinger believes he has additional cadaver data that includes T1 response and head neck system.
2. Rolf will also verify that the lateral bending moment was intentionally omitted from NHTSA's recommendations

TORSO - shoulder

1. Perpendicular and oblique pendulum test based on APR;
2. 7.2g sled test based on Ewing;
3. 8.9 m/s padded wall test based on WSU;
4. Quasi-static based on volunteer;
5. Drop tests based on APR

Discussion:

NHTSA proposes a 4" shoulder - thorax - pelvic lead low speed rigid (6.7 m/s) and high speed (8.9 m/s) padded test. A force time history is obtained for all wall segments to check that the environment is properly loaded. Additional requirements can include

acceleration based, deflection based. Displacement time history can be obtained from chest bands to check the response.

NHTSA & EEVC propose to eliminate the drop tests, since they are difficult to replicate and the padding is no longer available.

EEVC proposes to keep pendulum test with impactor force/time history and maximum deflection & quasi static tests.

EEVC drops test 4 {strong coupling between shoulder and T1} keep 7.2g sled require T1 acceleration (test 2)

This is inconsistent with previous section in the SID2000 document (which has not been reviewed yet by EEVC) Jac Wismans recommends that this not be dropped. The quasi static is based on volunteer (not really a test response) ROM is more a part of anthropometry.

Rolf Eppinger would prefer to keep this test for the moment until further data can be collected

TORSO - Thorax

1. pendulum at 4.3 m/s test based on HSRI;
2. pendulum at 6.7 m/s test based on WSU;
3. Drop test 1 m rigid based on APR;
4. Drop test 2 m padded based on APR;
5. Sled test 6.7 m/s rigid wall test based on Heidelberg;
6. Sled test 8.9 m/s padded wall based on WSU

Discussion:

Question: How does flat test differ from Wayne State & Heidelberg. More load cells have been added, similar to Wayne State.

EEVC keeps pendulum tests 1 & 2, drops test 3 & 4 and keeps Heidelberg test 5 (sled) and Wayne State test 6 (sled);

In time, if the new sled tests prove to be an improvement they can replace the original sled tests. The test procedures for the new NHTSA proposed tests need to be documented.

EEVC would be agreeable to replacing WSU & Heidelberg data with the new NHTSA data if it is acceptable;

This gave rise to a discussion on the effects of padding since WSU varied the characteristics of the padding and NHTSA used uniform padding;

Rolf Eppinger suggest making the rigid wall test mandatory and the padded test optional (rigid wall test will evaluate the impedance of the dummy.

Jac Wismans pointed out that padding results in a different load distribution and hence requires more biofidelity.

The general consensus is that it is too risky to ignore padding effect

conclusion:

- The members agree to include at least one rigid and one padded impact at more than one speed. Non-linear ystems are better approximated with 2 points.
- Keep pendulum test for shoulder, thorax and pelvis.
- If there is nothing inherently wrong with earlier data it should not be dropped.

Tasks

1. Rolf will check if NHTSA tests for Wayne State configuration were conducted with the arm up or down.

Discussion continued

NHTSA data: time histories have been provided in the appendix of document 4; ± 1 standard deviation corridors are preferred to straight line corridors.

At some points the corridors narrow to a width that would be extremely difficult to fit;

Time 0 marked at offset but this may be adversely affected by the morphology of the cadaver.

Corridor definition will depend on what injury criteria will be the driving factor; may need to be artificially inflated; issue needs to be looked at further.

TORSO - abdomen

1. 1m drop on rigid armrest
2. 2 m drop on rigid armrest
3. 6.7m/s rigid sled test based on WSU;
4. 8.9m/s rigid sled test based on WSU;
5. 8.9m/s padded sled test based on WSU;
6. Pendulum tests at 4.8, 6.8, 9.4 m/s based on Viano;
7. Impactor tests based on Talantikite.

Discussion:

EEVC recommends Viano pendulum and WSU padded test only.

PELVIS

1. Test 1 &2 pendulum impact at 6 and 10 m/s
2. Tests 3- 6 drop tests on rigid and padded surfaces
3. Tests 7- 9 Heidelberg sled;
4. Test 10-13 WSU sled.

Discussion

Drop the drop tests introduce the new NHTSA sled tests

EEVC proposes to include impactor tests, Heidelberg & WSU padded and rigid sled tests. Rolf Eppinger will review available data to see if there is sufficient data to establish future status/ inclusion of WSU and Heidelberg data.

Concluding Tasks:

1. Jac Wismans will obtain a revised draft of the SID2000 document ready for the presentation at the next IHRA biomechanics meeting.
2. Farid Bendjellal will look into available data for both lower and upper extremities.

6. Dummy evaluation methods

Jac Wismans presented dummy evaluation methods (published in an earlier IRCOBI) and tabled at EEVC WG 12;

There was general agreement that each body segment should be rated for every test independent of other segments;

Tasks

1. Rolf Eppinger has agreed to verify that data are still available to compare the Marcus method with the 4 methods proposed by EEVC;
2. Koshiro Ono will look at the methods and conduct a comparison by inputing curves and defining the merits of each.

7. Injury Criteria (Dominique Cesari)

Reviewed 3 documents from WG6 thorax and pelvis (2), dummy response (1). Propose to limit injury criteria to those body regions for which adequate data exists.

8. Other Business

EEVC proposed to have "frontal impact dummy developments" as an IHRA agenda item for the next meeting. It was agreed that EEVC and NHTSA would present their plans as a basis for future harmonization activities in this field at the next IHRA meeting in San Diego.

9. Next Meeting(s)

It is anticipated that the next meeting of the WG would be held in San Diego on October 28, 1999.

Close of Meeting

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List of Documents

All delegates are reminded that any documents previously tabled should be resubmitted to the Secretary so that they can be filed and numbered.